RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

3/27/2014

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 1067-7307 REVISION 4**
SRP SECTION:	**03.08.04 – Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/12/2013**

QUESTION NO. 03.08.04-59:

In Section 3.8.4.3.4.7, "Crane Loads," of Revision 4 of the DCD, the first paragraph states:

"Crane and equipment supplier's information are used to determine wheel loads, equipment loads, weights of moving parts, and reactions of clamps (if any). Construction loads are considered where applicable. Impact allowance for travelling crane supports and runway horizontal forces are in accordance with AISC N690 (Reference 3.8-9) for seismic Category I and II structures, unless the crane manufacture's design specifies higher impact loads."

The above statement lacks necessary details including the description of the design and analysis methods for the polar crane. The staff requests that the applicant provide the description of the design and analysis methods of the polar crane, including loads, load combinations, design criteria, assumptions, and COL information. The applicant is requested to revise the DCD to specify the COL parameters for the polar crane, and to update Section 3.8.4.3.4.7 of the DCD to provide the requested information.

ANSWER:

The polar crane design bases, specifications, and identification that the crane is over safety related equipment are identified in DCD Subsection 9.1.5.1, Table 9.1.5-2, and Table 9.1.5-4. Rules for design, analysis and construction of the crane are identified in ASME NOG-1 as required in DCD Sections 3.7.2.3.2 and Table 9.1.5-4. The requirement to confirm that the seismic response is enveloped by the conditions analyzed is identified as COL 3.7(11). The DCD identifies this crane as site specific with the requirement that it be designed by the COL Applicant. Consistent with the SRP, DCD Section 3.8.4.3.4.7 currently defines loads and load factors.

While the crane is a site specific design, loads and mass from a typical crane are considered in the design of the PCCV. Discussions during the 3.8 audit (November 4-8, 2013) and review of the DCD have identified the need for additional information and a new COL item be added to the DCD. This additional information will address the intent of this RAI, which is to identify within the DCD the loads and conditions that were considered in the design. Because the loads and mass are supported by the PCCV shell it was determined appropriate to document the effects from the crane in DCD Section 3.8.1. This is consistent with SRP Section 3.8.1.B, Major Structural Attachment because of the specific inclusion of the crane support bracket which is the structure that transfers the load from the crane to the PCCV.

Impact on DCD

Discussion of polar crane brackets and associate major loads are added to DCD Sub-section 3.8.1, and a new reference is added to Sub-section 3.8.7as shown in Attachment 1.

Impact on R-COLA

Site-Specific

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on the Technical/Topical Reports.

This completes MHI’s response to the NRC’s question.

QUESTION NO. 03.08.04-60:

In DCD Tier 2, Subsection 3.8.4.1.1, "R/B," the fourth paragraph states,

"The safety system pumps and heat exchanger areas are located at the lowest level of the R/B to secure the required net positive suction head. The safety system heat exchangers are located on the upper floor."

The staff considers this paragraph to be confusing because it appears to provide conflicting information for the location of the safety system heat exchangers. The applicant is requested to clarify the location of the safety system heat exchangers and to update the DCD appropriately.

ANSWER:

The safety system pumps take suction from the Refueling Water Storage Pit (RWSP) and are supported at the lower floor to meet the net positive suction head requirement. The elevation of the CS/RHR heat exchangers is on the upper floor.. DCD Section 3.8.4.1.1 has been clarified and attached to this response.

Impact on DCD

DCD Section 3.8.4.1.1 has been revised as indicated in Attachment 1.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on the Technical/Topical Reports.

This completes MHI's response to the NRC's question.

The liner anchorage system is designed so that its mechanical behavior is reasonably predictable for all design-basis loadings. The design and analysis procedures for the liner anchorage system conform to the ASME Code, Section III, Division 2 requirements given in Subarticles CC-3630 and CC-3730, and are similar to the anchorage system analysis approaches illustrated in BC-TOP-1 (Reference 3.8-17). Liner anchors are analyzed considering elastic behavior of the liner plate and non-linear behavior of liner anchors. In the cylinder, the liner is treated as a one-way strip in the hoop direction (analyzed uniaxially) with multiple continuous spans across liner anchors. Liner anchor spring behavior for the analysis of the liner-anchorage system are based on test results obtained from liner anchorage shear tests.

A non-linear analysis is performed to determine the maximum displacement in the liner anchor and the resultant stresses and strains in the liner. The analysis assumes that a buckle in the liner could occur at any location.

Two analyses are performed. In the first analysis, the buckle is assumed to occur in the membrane region and the thickness of the plate is ¼ inch on either side of the buckled panel. In the second analysis, the buckled panel is assumed to occur in the ¼ inch panel when it connects to a thickened panel at penetrations. The second analysis takes into account the larger forces imposed by the thicker panels and also incorporates the restraint provided by the penetrations. In both analyses, the restraint provided by the buckled panel is conservatively neglected.

Penetration Assemblies and Openings

For the penetration assemblies and openings, the US-APWR follows the ASME Code, Section III, Division 2 (Reference 3.8-2), requirements given in Subarticles CC-3640 and CC-3740. Penetration assemblies and openings, such as personnel airlocks, equipment hatch, and the fuel transfer tube assembly are analyzed using the same techniques and procedures as defined in Division 1 of ASME Code, Section III (Reference 3.8-2), where these components are not backed by concrete. The analysis considers the concrete confinement for the embedded portions of penetration sleeves as required by ASME Code, Section III.

3.8.1.4.5 Major Structural Attachments DCD_03.08.04-59

For brackets and attachments that form part of the liner system, the design and analysis procedures conform to the ASME Code, Section III requirements given in Subarticle CC-3650 (Reference 3.8-2). The PCCV design considers thirty (30) polar crane support brackets, consistent with Figure 3.8.3-8, spaced evenly around the inside perimeter of the PCCV wall to support the polar crane and polar crane girder/rails. It will be necessary to embed the brackets into the containment wall because of the magnitude of the applied load to each bracket. The Figure 3.8.3-8 crane bracket configuration transfers the applied loads to the PCCV in principal forces, i.e. shear, tension and compression. The applied moments in the bracket due to eccentric loading will be coupled into tension and compression areas within the lower crane bracket. The upper crane bracket is to provide lateral support to the polar crane and can transfer seismically induced compression and tangential shear to the PCCV shell. The brackets are to be constructed in accordance with Subsection 3.8.1.5.5, Brackets and Attachments and designed to consider the design live loads defined in Subsection 3.8.4.3.4.7. These supports do penetrate the liner DCD_03.08.04-59 plate, so, they will have a containment pressure boundary function. The liner plate is to be continuously welded to the embedded bracket plates and thickened liner plate areas so that a continuous leak tight barrier is maintained through these supports. DCD_03.08.04-59

The model used in the PCCV design considers the polar crane as a decoupled model because it is a site specific designed component and actual design loads are not available. The criteria to allow the two models to be decoupled are identified in Section 3.7.2.3.4. The dynamic analyses described in Section 3.7.2.3.2 will establish the crane mass and frequency and the COL Applicant is to confirm the acceptance to decouple the crane as part of the design (COL 3.8(36)).

The polar crane is a site specific item and the design loads will be dependent upon the configuration of the selected polar crane. Section 3.7.2.3.2 requires that the mass of the crane be enveloped within the seismic analyses. Additionally, the design load transferred to the PCCV from the anticipated crane is applied to two equivalent brackets at each end of the polar crane. The load distribution on the crane will be controlled by the design requirements of ASME NOG-1 (Reference 3.8-13). It is the responsibility of the COL Applicant to design the bracket such that the local stresses in the PCCV shell remain within ASME Section III Division 2 code allowable (COL 3.8(36)).

3.8.1.4.6 Design and Analysis Procedures for Impactive and Impulsive Loading

The methods of analysis for impactive and impulsive loading used on the PCCV and its liner are either an energy balance technique or a non-linear dynamic analysis with a forcing function that represents the impulsive and/or impactive loading condition. The empirical missile penetration formulas used are described in Section 3.5. For the PCCV and its liner, missile penetration is limited to well below 75% of the total section thickness while at the same time ensuring that the overall structural integrity of the section is not compromised. The PCCV nominal thickness dimensions of 4 ft, 4 in. for the cylinder and 3 ft, 8 in. minimum for the dome exceeds the required 16 in. thickness for Region 1 tornado missiles and for hurricane missiles with minimum concrete strength of 7,000 psi. Based on the robust nature of the PCCV, externally generated design-basis missiles including tornado missiles, as discussed in Section 3.5, do not challenge the PCCV cylinder or dome. The SG and pressurizer compartments protect the liner from direct missile impact. In other areas of the PCCV where a high-energy piping missile potential is not discounted due to the LBB analysis discussed in Subsection 3.6.3, missile shielding in accordance with Section 3.5 is utilized inside the PCCV to prevent missile impact on the liner.

3.8.1.4.7 Design Report

A Design Report of the PCCV is provided separately from the DCD. The Design Report has sufficient detail to show that the applicable stress limitations are satisfied when components are subjected to the design loading conditions.

3.8.1.5 Structural Acceptance Criteria

The PCCV, including its liner, is designed considering the loads and load combinations discussed in Subsection 3.8.1.3, and meets the structural acceptance criteria discussed in this subsection. The US-APWR PCCV structural acceptance criteria are based on the allowable displacements used are based on percentages of ultimate break displacement values obtained from shear load and pull-out testing of the liner anchorage system.

Penetration Assemblies

The acceptance criteria are the design allowables given in ASME Code, Section III (Reference 3.8-2), Subarticles CC-3740 and CC-3820.

In accordance with Subarticle CC-3740(b), the design allowables for penetration nozzles are the same as used for ASME Code, Section III, Division 1, where a nozzle is defined as that part of the penetration assembly not backed by concrete.

In accordance with Subarticle CC-3740(c), the design allowables for the liner in the vicinity of the penetration are the same as those given in the AISC Code for resisting mechanical loads in the service load category. For factored load categories, the allowables are increased by a factor of 1.5, except for impulse loads and impact effects.

In accordance with Subarticle CC-3740(d), the portion of the penetration sleeves backed by concrete is designed to meet the acceptance criteria described above for the liner plate and anchors. Additionally, consistent with requirements in Subarticle CC-3820, to verify acceptability, the structural capacities of penetration assemblies that are designed for pipe loads are compared against either (a) the ultimate moment, axial, torque, and shear loadings that the piping is capable of producing, or (b) penetration loads based on a dynamic analysis considering pipe rupture thrust as a function of time. In the case of (b), penetration designs are later verified using results of piping analysis to assure the load used in the design is not exceeded.

Typically for the US-APWR, in order to preclude pipe rupture effects, flued heads are used for high-energy piping if large applied pipe rupture design loads are anticipated. Detailed discussion on this topic is provided in Section 3.6.

Brackets and Attachments

The allowables given in the ASME Code, Section III (Reference 3.8-2), Subarticles CC-3650 and CC-3750 are used as the acceptance criteria for brackets and attachments to the liner.

The US-APWR design avoids the use of brackets and similar items that transmit loads to the liner in the through-thickness direction. ~~As much as practical in the design of attachments that have structural components carrying major loads, for example the upper plates of crane brackets, such a structural component of the attachment is made continuous through the liner. When through-thickness liner loads cannot be avoided and the liner is 1 in. or more in thickness,~~Structural components supporting major loads are to transmit the loads through the liner, to the extent possible, as opposed to attaching the load to the liner. A specific example is the top of the lower polar crane bracket directly transfers the tensile and shear loads through the liner into the PCCV shell as compared to the bottom of the same bracket which can transfer compression loads through the liner to the supporting PCCV concrete, see Figure 3.8.3-8. Dependent upon the loading it may be required to locally thicken the liner to maintain stresses and strains within code allowables. If the liner is thickened to 1 inch or greater then the special welding and DCD_03.08.04-59

COL 3.8(34) *The COL Applicant is to verify that lateral earth pressures used in the standard plant design envelope site-specific lateral earth pressures. The COL Applicant will satisfy the earth pressure enveloping criteria if the site specific earth pressure demands on the basemat exterior walls are enveloped by two standard design earth pressure loads.* MIC-04-03-00015

COL 3.8(35) *The COL applicant shall verify that: (1) the degree of compaction for the backfill placed beneath foundation has to be analyzed by field density tests only, since shear wave velocity or SPT measurements cannot be performed for such a thin layer of soil and (2) the friction resistance requirement, specified as a friction angle of at least 35°, is met.*

COL 3.8(36) *The COL applicant is to verify that the polar crane bracket does not locally overstress the PCCV concrete shell or its reinforcement when the crane load is distributed in accordance with NOG-1 and the crane load is applied to two equivalent crane brackets at each end of the crane.* DCD_03.08.04-59

3.8.7 References

3.8-1 Combined License Applications for Nuclear Power Plants (LWR Edition), RG 1.206, Rev. 0, U.S. Nuclear Regulatory Commission, Washington, DC, June 2007.

3.8-2 Rules for Construction of Nuclear Facility Components, Division 2, Concrete Containments. Section III, American Society of Mechanical Engineers, 2001 Edition through the 2003 Addenda (hereafter referred to as ASME Code).

3.8-3 Design Limits, Loading Combinations, Materials, Construction, and Testing of Concrete Containments. RG 1.136, Rev. 3, U.S. Nuclear Regulatory Commission, Washington, DC, March 2007.

3.8-4 Rules for Inservice Inspection of Nuclear Power Plant Components. Section XI, American Society of Mechanical Engineers, 2001 Edition through the 2003 Addenda.

3.8-5 Inservice Inspection of Ungrouted Tendons in Prestressed Concrete Containments. RG 1.35, Rev. 3, U.S. Nuclear Regulatory Commission, Washington, DC, July 1990.

3.8-6 Determining Prestressing Forces for Inservice Inspection of Prestressed Concrete Containments. RG 1.35.1, U.S. Nuclear Regulatory Commission, Washington, DC, July 1990.

3.8-7 Concrete Containment, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants. NUREG-0800 SRP 3.8.1, U.S. Nuclear Regulatory Commission, Washington, DC, March 2007.

3.8-8 Code Requirements for Nuclear Safety-Related Concrete Structures (ACI 349-06) and Commentary, American Concrete Institute, 2006.

3.8-9 Specification for the Design, Fabrication and Erection of Steel Safety-Related Structures for Nuclear Facilities, ANSI/AISC N690-1994 including Supplement 2 (2004), American National Standards Institute/American Institute of Steel Construction, 1994 & 2004.

3.8-10 Combustible Gas Control for Nuclear Power Reactors, Domestic Licensing of Production and Utilization Facilities, Energy. Title 10 Code of Federal Regulations Part 50.44, U.S. Nuclear Regulatory Commission, Washington, DC, January 1, 2007.

3.8-11 Control of Combustible Gas Concentrations in Containment, Regulatory Guide 1.7, Rev. 3, U.S. Nuclear Regulatory Commission, Washington, DC, March 2007.

3.8-12 Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs. SECY-93-087, U.S. Nuclear Regulatory Commission, Washington, DC, April 2, 1993.

3.8-13 Deleted.

3.8-14 ANSYS, Advanced Analysis Techniques Guide, Release 13.0, ANSYS, Inc., 2010.

3.8-15 Johnson, T.E. Testing of Large Pre-stressing Tendon End Anchor Anchorage Regions. International Conference on Experience in the Design, Construction and Operation of Pre-stressed Concrete Pressure Vessels and Containments for Nuclear Reactors, University of York, England, 8-12 September 1975.

3.8-16 ~~Deleted~~Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder), American Society of Mechanical Engineers, ASME-NOG-1 (i.e., Nuclear Overhead Gantry), New York, 2004. DCD_03.08.04-59

3.8-17 Containment Building Liner Plate Design Report, BC-TOP-1, Rev. 1, December 1972, Bechtel Corporation, San Francisco, California.

3.8-18 Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors, Domestic Licensing of Production and Utilization Facilities, Energy. Title 10 Code of Federal Regulations Part 50, Appendix J, U.S. Nuclear Regulatory Commission, Washington, DC.

3.8-19 Safety-Related Concrete Structures for Nuclear Power Plants (Other Than Reactor Vessels and Containments), Regulatory Guide 1.142, Rev. 2, U.S. Nuclear Regulatory Commission, Washington, DC, November 2001.

3.8-20 Concrete Radiation Shields for Nuclear Power Plants. Regulatory Guide 1.69, U.S. Nuclear Regulatory Commission, Washington, DC, December 1973.

3.8-21 Deleted.